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Feasibility Study of a FAARRS-SHARE Methodology for the U.S. Army Reserve

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14. ABSTRACT *(Maximum 200 words)*:

This report describes research into the feasibility of developing a Forecasting and Allocation of Army Recruiting Resources Study-Sequential Hierarchical Allocation of Resource Elements (FAARRS-SHARE) system for the U.S. Army Reserve. FAARRS-SHARE provides the Army's active component a means of analyzing the impact of recruiting resources on accessions and the ability to estimate the resources necessary to achieve specific accession levels. This study explores the feasibility of developing a Reserve FAARRS-SHARE system by examining the underlying models for the FAARRS-SHARE system and beginning an investigation of new, more appropriate methodologies. Building on new developments in sensitivity/stability analysis in Data Envelopment Analysis (DEA) formulations are developed for estimation of an approximate empirical production function for U.S. Army Reserve recruiting. Parameters of an empirical production function are estimated and reported.

15. SUBJECT TERMS

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Feasibility Study of a FAARRS-SHARE Methodology for the U.S. Army Reserve

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FOREWORD

The Forecasting and Allocation of Army Recruiting Resources Study-Sequential Hierarchical Allocation of Resource Elements (FAARRS-SHARE) system is used by U.S. Army Recruiting Command (USAREC) to facilitate the efficient allocation of active component recruiting resources. The Army also has a need to efficiently allocate the reserve component recruiting resources. This study explores the feasibility of using for the reserve component the FAARRS-SHARE methodologies developed for the active component. A reserve component FAARRS-SHARE system would provide USAREC with a means of analyzing the impact of recruiting resources on accessions, the ability to estimate the resources required to reach specific accession levels, as well as the ability to do analysis of the trade-off between recruiters and advertising.

The Selection and Assignment Research Unit of the U.S. Army Research Institute for the Behavioral and Social Sciences' Manpower and Personnel Research Division conducted this study under Task 1331, "Personnel Policy Analysis," as part of the Study and Analysis (6.6) program. The Directorate of Military Personnel Management requested this study. The findings of this study, which were provided to USAREC, will support the decision on the development of a reserve component version of the FAARRS-SHARE system.

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FEASIBILITY STUDY OF A FAARRS-SHARE METHODOLOGY FOR THE U.S. ARMY RESERVE

EXECUTIVE SUMMARY

Research Requirements:

The Army's recruiting resources allocation decisions are critical in an era of diminishing resources. The Army s recruiting community needed tools to aid them in the efficient and effective allocation of their limited resources. A methodology is required for both the active and reserve components that forecasts high-quality contracts given resource levels, estimates the resources required to achieve a given level of accessions, and measures the effects and interactions of management decisions. The Forecasting and Allocation of Army Recruiting Resources Study-Sequential Hierarchical Allocation of Resource Elements (FAARRS-SHARE) system provides this capability for the active component. There is a need for a similar system for the reserve component. This system will provide the Army with information it needs to make critical decisions in an environment of diminishing recruiting resources.

Procedure:

A new data envelopment analysis (DEA) approach that provides simultaneously efficiency evaluations and sensitivity or robustness measures are described. Building on this DEA approach, new formulations that combine goal programming and discriminant function techniques for estimation of an approximate empirical production for U.S. Army Reserve recruiting are presented. Solution procedures are then described. A quarterly fiscal year 1993 database containing factors that effect the production of nonprior service and prior service reserve accessions is used in the DEA analyses. These data include the following input factors: the number of reserve recruiters, the reserve mission, unemployment rate, local expenditures, target population, and reserve gross rating points for television, cable, radio, and print. Estimation of empirical production function was performed for the aggregate year-based efficiency results.

Findings:

Estimation of the empirical production function produces an elasticity of .83 for mission and .14 for unemployment with all other factors having negligible impacts on the production of nonprior service and prior service reserve accessions. In excluding reserve mission as a factor in the model, the effects of unemployment, local expenditures, and national advertising are approximately .10 with the recruiter elasticity between .70 and .76. The estimation device employed here is sound. However, the accuracy of the estimation results depends on there being a sufficient number of observations. Improvement in estimation results can be achieved with increases in the number of observations.

Utilization of Results:

These results can be used as the foundation for building an empirical production function for Army reserve recruiting. In addition, the new methodologies presented can be utilized to improve the Army active component FAARRS-SHARE system.

FEASIBILITY STUDY OF A FAARRS-SHARE METHODOLOGY FOR THE U.S. ARMY RESERVE

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FEASIBILITY STUDY OF A FAARRS-SHARE METHODOLOGY FOR THE U.S. ARMY RESERVE

Introduction

This report details research into a new methodology for the potential development of a Forecasting and Allocation of Army Recruiting Resources Study-Sequential Hierarchical Allocation of Resource Elements (FAARRS-SHARE) system for U.S. Army Reserve (USAR) use. The present work is motivated by the developments originally presented in Charnes, Golany, Pitaktong, and Rousseau (1991) and in enhanced form in Charnes, Kress, Golany, Pitaktong, and Rousseau, Semple, Song, and Zhou (1992) but differs from them in several significant respects. See also Thomas (1990).

The purpose of the original (FAARRS-SHARE) research was to develop a simple, rapid response methodology and accompanying software for forecasting, allocation and evaluation of annual Active Army recruiting resources at the aggregate headquarters Department of the Army (HQDA) level. Such a system was required in order to implement a multiyear program of desired accessions, or to quickly (within 72 hours) evaluate for congressional information the effects of suggested changes in accessions or in resource availabilities across such a multiyear program. Successful completion of the initial research and development of software was achieved in a six month period during fiscal year (FY) 1991, and the initial SHARE system has since been in practical use at both Office of Deputy chief of Staff of Personnel (ODCSPER) and U.S. Army Recruiting Command (USAREC).

As a result of this usage, additional features and capabilities, not previously requested by ODCSPER, were recognized as desirable and subsequently incorporated in the enhanced version. In addition, the methods and procedures developed in FAARRS-SHARE were viewed as potentially having wider applicability than just to the Active Component (AC).

The present research re-examines the underlying models of the FAARRS-SHARE system and begins investigation of a new, more appropriate methodology for developing such a system for Army Reserve use. The most recent developments in sensitivity/stability analysis in data envelopment analysis (DEA) are researched as the basic level of analysis. Building on this, other new and novel formulations are developed which combine goal programming and discriminant function techniques for estimation of an approximate empirical production function for U.S. Army Reserve recruiting.

The DEA-based micro analysis is a non-parametric methodology that requires no a priori model specification; the goal programming-discriminant function procedures involve analytical or parametric solutions -- hence we call this a "semi-parametric" method.

This report is organized as follows. The following two sections provide the necessary background on FAARRS-SHARE and a discussion of its applicability to the Army Reserve that

lead to the development of our new approach. The fundamental DEA analyses are discussed in the fourth section, followed by our new methods for empirical production function estimation. The sixth section discusses data issues associated with implementation of our procedures using FY 1993 data, and a seventh section presents our results. A final section summarizes our main findings and points towards some further avenues of research.

Background

As discussed in Charnes et al. (1991) and Charnes et al. (1992) the Army recruiting battalion is the "lowest" management element that has direct control over primary resource decisions that lead to "production" of contracts for Army service. Moreover, since the recent downsizing trend in Army strength coupled with drastic reductions in defense budgets required forecasting across much lower accession levels than in previous recruitment, better instruments needed to be developed that would be consistent with USAREC command and control recruitment management and not conflict with USAREC experience. Meeting these requirements made possible the new "multiplicative aggregation" method developed in Charnes et al. (1991) and Charnes et al. (1992) and Thomas (1990) for FAARRS-SHARE which permits one to go not only from battalion to total command but also from quarterly accessions to multiple quarters and to yearly accessions.

The FAARRS-SHARE process employs a multiplicative Data Envelopment Analysis (DEA) model to:

(a) approximate an empirical production function;

(b) determine the most consistently best performing battalions (BNs); and

(c) achieve therefrom, by a constrained weighted least absolute value method ('goal enhancement'), the relative rates of change ('elasticities') in optimal (so-called 'technically efficient') performance of recruiting resource and environmental elements.

This methodology overcomes several problems frequently associated with traditional statistical regression approaches to estimation. The problem of model mispecification (i.e., incorrect choice of inputs or outputs) is obviated here by more than fifteen years experience with USAREC data and recruiting activities. A second potential difficulty concerns the robustness of the objective function criterion. Here we use weighted least absolute value rather than the very sensitive least squares or maximum likelihood to ensure robustness. A third problem can be that of collinearity or lack of independence of inputs and of outputs. Here the absolute value criterion plus constraints to ensure valid specification minimized this problem compared to using least squares or maximum likelihood.

Potential Applicability To Army Reserve

We began initial investigations of what would likely be involved in extending the methodology to USAR recruiting. Here we sought to identify general data requirements, determine data availability and integrity, and familiarize ourselves with the special characteristics and nuances of USAR recruiting which could become problem areas. We can summarize our findings as follows.

Generally, the same kinds of core resources are required to secure quality Reserve recruits as are for AC recruits, but their differential effects may be quite different in the two cases. Moreover, we can expect additional factors, not so relevant in the AC case, to have an impact in the Reserve situation. For example, the role of potential differentials between civilian and military pay in the market will need to be examined closely, and the issue of market proximity to USAR centers will have to be explored.

Other issues further complicate matters. Several DEA analyses would likely be necessary in order to determine whether the AC (and perhaps the National Guard) should be treated as competition in Reserve recruiting. Competition from the other reserve components is also an important consideration, but what little information there is on competitive activity is of poor quality. For example, the presence and extent of competitive activity at the battalion level is unknown, and it is unclear whether the other service reserve components can provide that information.

Many of the dollar expenditures on automation, communications, the delay entry program (DEP), facilities, vehicles, advertising, etc. incurred by higher echelons of management also support the USAR, so developing an appropriate allocation of cost in each funding area will be a major factor.

In addition to such considerations, there is also the basic question of the continued validation of the mathematical procedures underlying FAARRS-SHARE. This is briefly discussed next.

Appropriateness of the FAARRS-SHARE Methodology

As innovative as the original FAARRS-SHARE models were, recent developments in DEA and related techniques for empirical production function estimation suggest that significant improvements to the methodology are now possible.

These improvements begin at the most fundamental level with superior techniques for conducting the basic DEA analyses and determining the most robustly efficient recruiting battalions which will drive estimation of the empirical production function. These new methods, which incorporate notions of sensitivity or stability in DEA efficiency classifications, are discussed in the next section.

Equally significant are the new formulations for production function estimation which combine in a novel way ideas from goal programming with those from the use of discriminant functions. These procedures are detailed below.

DEA Analyses

Data Envelopment Analysis (DEA) performed at the recruiting battalion level is the basic building block for our proposed methodology. However, unlike the previous FAARRS-SHARE research, the fundamental DEA analyses were here conducted using new formulations that provide *simultaneously* the required efficiency evaluations in addition to important measures of the sensitivity or robustness of the efficiency classifications (see references Charnes, Rousseau, and Semple (1995) and Rousseau and Semple (1995)).

A frequent criticism of the DEA results is that they present only a snapshot of a unit's situation, disregarding the effects of errors in the data, both real and induced, and the transitory nature of efficiencies in general. Lost, therefore, is any indication of whether the classification is fleeting or robust. Without this sensitivity information, therefore, findings can be distorted when marginally efficient or inefficient units are distinguished solely on the basis of their classification. To account for this additional factor without introducing distributional assumptions on the data, we employ the particular sensitivity analysis discussed in Charnes et al. (1995) and illustrated in Rousseau et al. (1995).

In this new sensitivity approach, the unit's observed input-output levels serve as the center of a ball (or cell) in the multi-dimensional input-output space. The largest ball for which the interior contains strictly classification preserving levels (with respect to the remaining unperturbed reference group) is then computed. We call the radius of this maximal ball the radius of classification preservation (RCP) and interpret it as a measure of the robustness of the DEA classification. Moreover, when either the l_1 or l-infinity (Tchebycheff) norm is used to describe the ball, the computations involve solving, at worst, a finite number of related linear programs.

It is important to realize that the values of these radii also answer a fundamental question: what is the minimum distance the analyzed unit must be moved to alter its classification? Therefore, like the efficiency score, which is based upon the principle of maximizing the separation between a unit and the reference points that dominate it, the radius of classification preservation is motivated by a particular extremal property. However, unlike the efficiency score, the radii can be used to discriminate among efficient units and reveal important differences among inefficient units.

The linear program (TR) (T for Tchebycheff, R for radius) below provides the necessary computations for efficient and inefficient units alike (with index k)

The superscripted index indicates that the associated column has been omitted from the matrices of observed outputs (Y) and inputs (X), without regard to, or prior knowledge of, the test unit's classification. The magnitude of the optimal value represents the minimum *absolute* change needed to place the test unit infinitesimally close to reclassification. The absolute value of the optimal value to (TR) is referred to as the unit's Tchebycheff radius of classification preservation.

An alternative approach is to compute the minimum *relative* change needed to effect reclassification. In this case, the vectors e_s and e_m are replaced by the vectors y_k and x_k, respectively in (TR). The ball is no longer associated with the Tchebycheff norm but rather a generalized Tchebycheff norm, which includes weights on the individual dimensions of the vector. If the test unit's inputs and outputs are used as the source of the weights, then the formulation which computes the *percentage* change needed simultaneously in all inputs and outputs to effect reclassification, for efficient and inefficient units alike, is given by the linear program (GTR).

$$
\begin{aligned}
& Min\ \alpha^{+} - \alpha^{-} \\
& Subject\ to \\
& Y(k)\lambda - s^{+} + \alpha^{+} y_k - \alpha^{-} y_k = y_k \\
& X(k)\lambda - s^{+} + \alpha^{+} x_k - \alpha^{-} x_k = x_k \qquad \text{(GTR)} \\
& e^{t}\lambda \qquad\qquad\qquad\qquad\quad = 1 \\
& \lambda,,\ s^{+}, s^{-}, \alpha^{+}, \alpha^{-} \geq 0.
\end{aligned}
$$

The absolute value of the optimal value to (GTR) will be referred to as the unit's generalized Tchebycheff radius of classification preservation.

At least one input or output dimension must be worsened by more than the computed RCP to achieve reclassification; worsening every input and output simultaneously by more than this value does bring about reclassification.

Our interest in (TR) and (GTR) is not limited to their obvious computational advantages. The optimal value to each provides a more comprehensive evaluation of the unit than a simple efficiency score. The sign of the optimal value indicates the classification of the test unit: a negative sign identifies inefficient units, a positive sign identifies efficient units. Therefore, (TR) and (GTR) are stand-alone DEA models with the advantage that efficiency classifications and sensitivity information are computed *simultaneously*.

Equally important is the magnitude of the optimal value since it addresses the robustness of the classification. If interest centers on the likelihood of a classification maintaining its current status in the future, then the magnitude of the optimal value becomes an important indicator.

The RCPs are further important since they can be used to distinguish among units with identical classifications. This will be particularly relevant in the research of the next section

where a satisfactory division of recruiting battalions into efficient and inefficient groups forms the basis for estimation of the empirical production function.

These new DEA formulations have several other advantages:

- There is no need to generate and then justify specific efficiency scores obtained from a particular DEA model.

- The programs can be implemented using any LP solver without recourse to any existing DEA code.

- Subsequent analysis of the RCPs may become important.

- Having programs (TR) and (GTR) as a point of departure may help suggest and motivate other applications of this type.

Much of classical single-output production theory is centered on fitting a production function to the observed data, otherwise known as the econometric-regression approach. After a function has been determined with a suitable fit, individual units are assessed by measuring the difference between their observed output and the value computed by the theoretical production function. This difference is the error or 'residual' for the unit and represents the distance separating observed from theoretically efficient production.

In the more complicated multi-output case of DEA, the production function is replaced by an input-output correspondence, also determined by the sample data, which defines Pareto efficient production. Because the radius of classification preservation measures the distance separating each unit from reclassification, it constitutes a generalization of the residual encountered in the single output production case. The importance of these residuals for future research and analysis will be discussed further in our Summary.

Empirical Production Function Estimation

The ability to represent, even in approximate form, the recruiting input-output relations by means of a frontier function is an important step in using historical data (observed inputs and outputs) for current and future managerial planning. For example, resource allocation and reallocation across recruiting battalions can be based on the frontier function. Questions of priorities, relative importance of production factors and goal setting can all be addressed using this function.

This section adapts to the DEA context a goal programming model developed by Freed and Glover (1981) as a general purpose instrument for discriminating among specified groups of observations. For a complete discussion, see Golany and Yu (1995) and references therein. The data for the model include a vector of observed values for each entity (here a recruiting battalion) and its association with one of several groups. In the present case we consider only two groups:

efficient and inefficient battalions. To associate each evaluated battalion with either the efficient (E) or inefficient group, we apply the (TR) or (GTR) models of the previous section.

We then apply a variant of the model developed by Freed and Glover to estimate the parameters of the discriminant function. The original model considered A_j, j = 1, ..., n observations organized into groups G_k, k = 1, ..., g. A pair-wise (i.e., g = 2) variant of the model was formulated as:

$$
\begin{aligned}
& Min \ \sum h_j \alpha_j - \sum c_j \delta_j \\
& subject\ to \\
& A_j X - \alpha_j + \delta_j = b, \quad j \in G_1 \\
& A_j X - \alpha_j + \delta_j = b, \quad j \in G_2 \\
& \alpha_j, \delta_j \geq 0, \ X \neq 0
\end{aligned}
$$

where X represents a linear predictor (or a weighting scheme), b is a scalar breakpoint between the two groups, α_j are misclassification deviations that are minimized and δ_j are desired deviations which are maximized in the objective function which uses h_j and c_j as weights.

The model selects a separating hyperplane AX = b in a way that attempts not only to have all the units in one group above it and all units in the other group below it (by minimizing the α_j deviations) but also to 'push' the units in the respective groups as far away as possible from the hyperplane (by maximizing the δ_j deviations) so as to provide the sharpest possible distinction.

The input-output relations in DEA are characterized by a piece-wise concave empirical function, so the model above must be transformed to convert the concave relations assumed for DEA into a linear function. Here we use a Translog transformation which has the advantages of being general and allowing for synergy effects among the inputs to be formulated explicitly. Hence we define the observations A_j as follows:

$$
A_j = \begin{cases} \log(Y_{rj}), & \mathrm{r} = 1,\ldots,\mathrm{s} \\ \text{-}\log(\mathrm{X}_{\mathrm{ij}}), & \mathrm{i} = 1,\ldots,m \\ \text{-}\log(\mathrm{X}_{\mathrm{ij}})\log(X_{kj}), & \mathrm{i,k} = 1,\ldots,m \end{cases}
$$

The groups are defined as

G_2 = E (the set of efficient battalions)

G_1 = I (the set of inefficient battalions)

and the linear predictor is given by

$X = (\mu, \nu)$.

Thus our Translog function can be expressed as

$$\sum_r \log(Y_{rj})\mu_r = \beta + \sum_i \log(X_{ij})v_i + \sum_i \sum_k \log(X_{ij})\log(X_{kj})v_{ik},\ j = 1,\ldots n \qquad (TL).$$

Without loss of generality we normalize the v variables to prevent an 'all-zero' solution. This results in the following general model (G):

$$\begin{aligned}
&Min\ \sum_{j\in I} h_{ij}\alpha_j + \sum_{j\in E} h_{2j}\alpha_j - \sum_{j\in I} c_{1j}\delta_j - \sum_{j\in E} c_{2j}\delta_j \\
&Subject\ to \\
&\sum_r \log(Y_{rj})\mu_r - \sum_i \log(X_{ij})\upsilon_r - \sum_i \sum_k \log((X_{ij})\log(X_{kj})\upsilon_{ik} - \alpha_j + \delta_j = \beta,\ j \in I \\
&\sum_r \log(Y_{rj})\mu_r - \sum_i \log(X_{ij})\upsilon_r - \sum_i \sum_k \log((X_{ij})\log(X_{kj})\upsilon_{ik} - \alpha_j + \delta_j = \beta,\ j \in E \qquad (G) \\
&\sum_i \upsilon_i + \sum_i \sum_k \upsilon_{ik} = 1 \\
&\beta_j, \delta_j \geq 0, \forall j.
\end{aligned}$$

Solution Procedure

Based on our development above we now propose the following procedure to identify the parameters of a Translog function which can serve as a surrogate for the empirical production function in recruiting.

Step 1. Solve (TR) or (GTR) and associate the recruiting battalions with the sets E and I.

Step 2. Solve the following variant of the general model (G) above.

$$\begin{aligned}
&Min\ z \\
&Subject\ to \\
&\sum_r \log(Y_{rj})\mu_r - \sum_i \log(X_{ij})\upsilon_r - \sum_i \sum_k \log((X_{ij})\log(X_{kj})\upsilon_{ik} \qquad \leq \beta \quad j \in I \\
&\sum_r \log(Y_{rj})\mu_r - \sum_i \log(X_{ij})\upsilon_r - \sum_i \sum_k \log((X_{ij})\log(X_{kj})\upsilon_{ik} - \alpha_j + \delta_j = \beta,\ j \in E \\
&\alpha_j \leq z,\ j \in E \\
&\sum_i \upsilon_i + \sum_i \sum_k \upsilon_{ik} = 1 \\
&\alpha_j, \delta_j \geq 0, \forall j.
\end{aligned}$$

Drop from consideration all battalions in E with $z = \alpha j^*$.

Repeat Step 2 until $z = 0$ or $|E| \leq \rho$, that is. until no further misclassification errors are observed for the battalions in E or until the number of remaining battalions in E has reached a prescribed minimal level ρ.

Step 3. Solve the following variant of the general model (G) above.

$$Min \sum_{j \in E} (\alpha_j + \delta_j)$$

Subject to

$$\sum_r \log(Y_{rj})\mu_r - \sum_i \log(X_{ij})\upsilon_r - \sum_i \sum_k \log((X_{ij})\log(X_{kj})\upsilon_{ik} \qquad \leq \beta \quad j \in I$$

$$\sum_r \log(Y_{rj})\mu_r - \sum_i \log(X_{ij})\upsilon_r - \sum_i \sum_k \log((X_{ij})\log(X_{kj})\upsilon_{ik} - \alpha_j + \delta_j = \beta, \; j \in E$$

$$\sum_i \upsilon_i + \sum_i \sum_k \upsilon_{ik} = 1$$

$$\alpha_j, \delta_j \geq 0, \forall j.$$

A key to understanding the procedure above is the realization that DEA, being a *relative* efficiency method, is more likely to misclassify as efficient battalions which actually are inefficient according to an *absolute* standard rather than the reverse case. When DEA identifies a unit as inefficient, this means that evidence has been found that other units dominate it. On the other hand, when DEA identifies a unit as efficient this means only that no such evidence of domination has been found in the observed data, but this does not imply that this unit is indeed necessarily efficient with respect to the unknown production function.

Thus the purpose of Step 2 above, which may be repeated several times, is to drop battalions in set E from further consideration if they are suspected of being misclassified into E. In Step 2 we identify in each iteration the battalions that are associated with the largest misclassification error and drop them from set E. This step is repeated until no further misclassification errors are observed for the battalions in E or until the number of remaining battalions in E has reached a prescribed minimal level ρ.

Step 3 continues to enforce the separation that was attained earlier (in particular, it allows no misclassification errors for battalions in I) while attempting to fit a hyperplane through the reduced set of efficient battalions. In that context, Step 3 can be viewed as a Minimum Absolute Deviation (MAD) regression applied to E with side constraints related to battalions in I.

Refinements

Our solution procedure can be refined by directly incorporating the sensitivity information provided by (TR) or (GTR).

The individual radii of classification preservation can be used to form the weights h_{1j}, h_{2j}, c_{1j} and c_{2j} in the objective function of the general model (GM). Thus the desirable deviations δ_j and the undesirable deviations α_j can be given weights that reflect the robustness of battalion j's classification as efficient or inefficient.

Alternatively, the radii of classification preservation can be used to partition the battalions into finer groupings. The efficient battalions might be partitioned into sets E^1, E^2, ...,

E^e according to the magnitudes of the radii, for example, E^1 might contain the upper decile and E^e the lowest decile. Likewise, the inefficient battalions might be grouped into I^1 (upper ten percent), ..., I^i (lowest ten percent). The groupings in which we would have the most confidence are E^1 (most robustly efficient) and I^1 (most robustly inefficient). The potential for misclassification is greatest with sets E^e and I^i. Accordingly, these latter four groups of battalions might be singled out for special treatment (in different ways and for different reasons) in the model constraints. A variety of other possibilities are also available.

Data Issues

Following is a list of outputs and inputs used in our initial analyses. Data were available for each quarter of FY 1993. In that year there was a 42 battalion structure.

Outputs

Non-Prior Service (NPS) contracts - male plus female, all categories
Prior Service (PS) contracts - male plus female, all categories

Inputs

USAR Recruiters
Reserve Mission
Unemployment Rate
USAR Local Expenditures
Target Population
USAR Aggregate Advertising Gross Rating Points (GRPs)
- TV
- Cable
- Radio
- Print

Several other input factors were considered but could not be used due to lack of available or reliable data. Significant among these were measures of competitive activity (e.g., from the national guard) and the civilian/military wage differential. Regarding the latter, there are potential difficulties in its measurement. Determining the appropriate civilian occupational categories is one issue; combining or somehow averaging wage rates for different occupations is another; averaging the result across distinct regions in a battalion is yet another. Moreover, no data on wage rates were available to us.

Even for the inputs used, some issues are still unresolved. For example, it is not clear that the target population age group is precisely the same as that for which advertising GRPs are reported. The input actually used in the DEA is impressions (= GRPs x target population), so this potential mismatch may be detrimental to the analysis. In addition, an unemployment rate for the target population was not available to us and a general unemployment rate had to suffice as a surrogate.

In these preliminary efforts we are seeking to determine the appropriateness of our general procedures for evaluation of Reserve recruiting activities. Consequently, for the early DEA runs we chose to use aggregate advertising GRPs as an input rather than also attempt to unravel the media mix issues through having separate inputs for each medium.

Results

Efficiency Results

The DEA runs were carried out using (GTR) for each of the four quarters of FY 1993 and on aggregate data for the year as a whole. The efficiency results are summarized in Tables A1-A5 in the Appendix. Recall from the DEA Analyses section that the sign of a battalion's alpha value (column three of each table) indicates its efficiency classification: positive alpha indicates efficient, negative indicates inefficient.

Recall also that the absolute value of alpha represents the robustness of the classification. Accordingly, in quarter 1 of FY 1993 (see Table A1) Battalion 17 would have required across-the-board changes to inputs and outputs in excess of 22% in order to have been classified as inefficient, while Battalion 42 would have required changes of only 5%. Likewise, inefficient Battalion 18 was only marginally so, requiring simultaneous improvements in inputs and outputs of only 1% in order to effect reclassification. However, Battalion 39 would have needed improvements of 30% to have been reclassified as efficient.

Also shown in Tables A1-A5 are the "proportion of mission achieved" and "write rate" for each battalion and for the Reserve recruiting command as a whole, by quarter and annually. In each case, the figures are given for Non-Prior Service contracts and Prior Service contracts as well as in aggregate. These two factors may be viewed as measures of recruiting effectiveness, not to be confused with recruiting efficiency. We will return to this in more detail later.

Summary Table 1 indicates that there are both temporal and geographic differences in recruiting performance. In FY 1993 fifteen battalions were efficient in quarter 1, sixteen in quarter 2, twenty in quarter 3, eleven in quarter 4, and fourteen battalions were efficient over the aggregate year. Four battalions (Battalion 2, Battalion 14, Battalion 36, Battalion 38) were efficient in all four quarters and in aggregate for the year as a whole.

A further five battalions (Battalion 17, Battalion 22, Battalion 27, Battalion 35, Battalion 42) were efficient in three of the four quarters, but only the middle three were also efficient on an annual basis (although the classification of both Battalion 17 and Battalion 42 was indeterminate, i.e., with an annual alpha value of zero). Seven more battalions (Battalion 4,

Table 1

Efficient Battalions FY 1993

BN		Q1	Q2	Q3	Q4	FY
Battalion	1					
Battalion	2	X	X	X	X	X
Battalion	3					
Battalion	4		X	X		X
Battalion	5				X	
Battalion	6			X	X	X
Battalion	7					
Battalion	8					
Battalion	9	X		X		X
Battalion	10	X		X		X
Battalion	11			X	X	X
Battalion	12					
Battalion	13	X	X			X
Battalion	14	X	X	X	X	X
Battalion	15	X				
Battalion	16				X	
Battalion	17	X	X	X		
Battalion	18			X		
Battalion	19			X		
Battalion	20					
Battalion	21	X	X			
Battalion	22	X	X	X		X
Battalion	23		X			
Battalion	24					
Battalion	25					
Battalion	26					
Battalion	27	X	X	X		X
Battalion	28			X		
Battalion	29	X				
Battalion	30					
Battalion	31			X	X	
Battalion	32					
Battalion	33			X		
Battalion	34	X	X			
Battalion	35		X	X	X	X
Battalion	36	X	X	X	X	X
Battalion	37			X	X	X
Battalion	38	X	X	X	X	X
Battalion	39					
Battalion	40	X				
Battalion	41		X			
Battalion	42	X	X	X		
		15	16	20	11	14

Battalion 6, Battalion 9, Battalion 10, Battalion 11, Battalion 13 and Battalion 37) were efficient on an annual basis even though they were efficient in only two of the quarters. Twelve battalions were never efficient in any quarter.

The 42 recruiting battalions are grouped regionally into four Brigades: Brigade A has 13 battalions, Brigade B has 8, Brigade C has 10, and Brigade D contains 11 battalions. We can think of a given battalion in a specified quarter as one opportunity for the battalion's associated Brigade to excel. Forming the ratio of such efficiency successes to the Brigade's number of opportunities provides a measure of Brigade "efficiency success" for each quarter and annually. For example, in quarter 1 Brigade C had three efficient battalions out of its ten. Hence its efficiency success rating in quarter 1 is 0.30. On an annual basis five of its battalions were efficient so its annual efficiency rating is 0.50. The Table 2 summarizes this information.

Table 2

Brigade Efficiency Success

	Q1	**Q2**	**Q3**	**Q4**	**Mean**	**FY 93**
Brigade A	.62	.462	.462	.231	.404	.308
Brigade B	.50	.625	.625	.50	.563	.50
Brigade C	.30	.20	.50	.30	.325	.50
Brigade D	.182	.273	.364	.091	.227	.091
Command	.357	.381	.476	.262	.369	.333

Brigade B is consistently best by this efficiency success measure, in every quarter and annually. In contrast Brigade D is consistently the worst (except for quarter 2 when it is second to last by this measure).

It is instructive to compare the aforementioned measures of effectiveness (viz., proportion of mission achieved and write rate) to the efficiency classifications obtained from the DEA to discern any patterns that may be present. Tables 3-5 provide summary results for NPS, PS and total contracts.

In each case, although inefficient battalions can and do achieve mission and have respectable write rates, this tends to be more evident among efficient battalions. Likewise, low write rates and low proportions of mission achieved are far more common among inefficient battalions. The general conclusion drawn is that efficiency is positively related to but not equivalent to effectiveness.

Table 3

NPS Summary Rresults FY
1993

	Proportion Mission Achieved			Quarterly Write Rate			
	≥ 1.00	0.75 - 0.99	≤.74	≥ 5.00	4.00 - 4.99	3.00 - 3.99	< 3.0
Quarter 1							
15 Efficient BNs	7	6	2	2	5	6	2
27 Inefficient BNs	8	13	6		8	17	2
Command		0.86				3.64	
Quarter 2							
16 Efficient BNs	13	2	1	11	4	1	
26 Inefficient BNs	19	7		18	6	2	
Command	1.12			5.17			
Quarter 3							
20 Efficient BNs	10	6	4	3	11	2	4
22 Inefficient BNs	11	8	3	3	7	11	1
Command		0.97			4.04		
Quarter 4							
11 Efficient BNs	10	1		5	1	3	2
31 Inefficient BNs	27	3	1	3	16	9	3
Command	1.28				4.44		

	Proportion Mission Achieved			Annual Write Rate			
	≥ 1.00	0.75 - 0.99	≤ 0.74	≥ 20.00	16.00 - 19.99	12.00 - 15.99	< 12.0
FY 1993							
14 Efficient BNs	12	1	1	5	6	3	
28 Inefficient BNs	15	11	2	4	15	7	2
Command	1.04				17.27		

Table 4

PS Summary Results FY 1993

	Proportion Mission Achieved			Quarterly Write Rate			
	≥1.00	0.75 - 0.99	≤ 0.74	≥5.00	4.00 - 4.99	3.00 - 3.99	< 3.0
Quarter 1							
15 Efficient BNs	13	2		5	5	5	
27 Inefficient BNs	18	9		5	8	10	4
Command	1.1				4.03		
Quarter 2							
16 Efficient BNs	11	4	1	7	4	5	
26 Inefficient BNs	9	12	5	3	12	9	2
Command		0.93			4.18		
Quarter 3							
20 Efficient BNs	15	4	1	10	5	5	
22 Inefficient BNs	7	10	5		11	7	4
Command		0.94			4.07		
Quarter 4							
11 Efficient BNs	8	2	1	5		5	1
31 Inefficient BNs	19	7	5	8	12	8	3
Command		0.99			4.5		

	Proportion Mission Achieved			Annual Write Rate			
	≥1.00	0.75 - 0.99	≤ 0.74	≥ 20.00	16.00 - 19.99	12.00- 5.99	< 12.0
FY 1993							
14 Efficient BNs	12	2		7	2	5	
28 Inefficient BNs	14	10	4	4	9	13	2
Command		0.99			16.76		

Tabl e 5

NPS + PS Summary Results FY 1993

	Proportion Mission Achieved			Quarterly Write Rate			
	≥ 1.00	0.75 - 0.99	≤ 0.74	≥ 10.00	8.00 - 9.99	6.00 - 7.99	< 6.0
Quarter 1							
15 Efficient BNs	11	4		3	7	5	
27 Inefficient BNs	13	12	2		11	14	2
Command		0.97				7.67	
Quarter 2							
16 Efficient BNs	15	1		9	7		
26 Inefficient BNs	15	10	1	6	16	4	
Command	1.03				9.35		
Quarter 3							
20 Efficient BNs	17	3		3	16		1
22 Inefficient BNs	10	8	4		10	11	1
Command		0.96			8.11		
Quarter 4							
11 Efficient BNs	11			2	7	2	
31 Inefficient BNs	24	7			23	7	1
Command	1.12				8.94		

	Proportion Mission Achieved			Annual Write Rate			
	≥ 1.00	0.75 - 0.99	≤ 0.74	≥ 40.00	32.00 - 39.99	24.00 - 31.99	<24.0
FY 1993							
14 Efficient BNs	14			3	10	1	
28 Inefficient BNs	17	10	1	2	16	9	1
Command	1.02				34.03		

For comparison purposes, an efficiency analysis was also conducted, based on annual figures, using a single output, the sum of NPS and PS contracts. This reduction in the number of input-output dimensions plus the increased discriminatory power of the new DEA models halves the number of efficient battalions from 14 to 7. Table 6 shows a comparison of the efficient battalions using two outputs and a single output.

As already discussed in the DEA Analyses section, the efficiency (sensitivity/stability) alpha values provide a natural means for ranking the battalions (recall positive alpha indicates efficient, negative indicates inefficient). A comparison of battalion alpha values and efficiency rankings under two outputs and a single output is shown in Table 7. Although the absolute values of the alphas can be expected to differ between the two cases (as seen here), an inspection of the two rankings shows them to be very similar. This is particularly evident for the robustly efficient and robustly inefficient battalions. This conclusion is further illustrated by the individual battalion-by-battalion comparisons shown in Table 8.

Production Function Estimation Results

Our intent here is to investigate the potential of one method (described in detail in the Empirical Production Function Estimation section for estimating an empirical efficient production function for Reserve recruiting and thereby obtain estimates of "rates of change" or elasticities for the various recruiting resources and environmental factors in technically efficient recruiting.

As anticipated (and confirmed in our applications) the increased discriminatory power of our new (TR) and (GTR) DEA models allows us to go directly to Step 3 of the solution procedure discussed in the Empirical Production Function Estimation section of this paper. Estimation of the empirical efficient production function was performed for the aggregate year based on the efficiency results of Table A5. Fourteen battalions were efficient. This limited number of observations made it necessary to curtail the estimation to include only the direct input effects (ignoring the interactive effects). Even so, difficulties with non-uniqueness can still be expected since there are eight parameters to be estimated - one for each input and output plus a multiplicative constant (see the Empirical Production Function Estimation section).

To illustrate the point, the basic version of our goal program (i.e., without additional restrictions applied to the elasticities) almost fully accounted for efficient production by assigning an elasticity of 0.83 to the input mission. In this run the elasticity for unemployment rate at 0.14 was the only other influential factor. The recruiter effects appear to have been completely subsumed by the effect of the mission. This can be explained by observing that the efficient battalions as a group achieved or exceeded mission so that relating production directly to mission was straightforward.

This situation can be remedied by applying additional considerations, for example, to bound elasticities away from zero and to constrain elasticities to fall within fairly broad ranges reflecting recruiting experience. However, this also raises the question of whether mission should be considered a valid input in this process. In separate runs excluding mission as a factor,

Table 6

Efficient Battalions Comparison FY 1993

BN	Two Outputs	One Output
Battalion 1		
Battalion 2	X	X
Battalion 3		
Battalion 4	X	
Battalion 5		
Battalion 6	X	
Battalion 7		
Battalion 8		
Battalion 9	X	
Battalion 10	X	
Battalion 11	X	X
Battalion 12		
Battalion 13	X	X
Battalion 14	X	X
Battalion 15		
Battalion 16		
Battalion 17		
Battalion 18		
Battalion 19		
Battalion 20		
Battalion 21		
Battalion 22	X	
Battalion 23		
Battalion 24		
Battalion 25		
Battalion 26		
Battalion 27	X	
Battalion 28		
Battalion 29		
Battalion 30		
Battalion 31		
Battalion 32		
Battalion 33		
Battalion 34		
Battalion 35	X	
Battalion 36	X	X
Battalion 37	X	X
Battalion 38	X	X
Battalion 39		
Battalion 40		
Battalion 41		
Battalion 42		
Total Efficient	14	7

Table 7

Battallion Alpha Value Comparison FY 1993

Two Outputs

BN	Alpha	Rank
Battalion 11	0.31	1
Battalion 38	0.29	2
Battalion 2	0.21	3
Battalion 14	0.11	4
Battalion 13	0.03	5
Battalion 27	0.03	5
Battalion 9	0.02	7
Battalion 37	0.02	7
Battalion 4	0.01	9
Battalion 6	0.01	9
Battalion 10	0.01	9
Battalion 22	0.01	9
Battalion 35	0.01	9
Battalion 36	0.01	9
Battalion 17	0.00	15
Battalion 42	0.00	15
Battalion 15	-0.01	17
Battalion 16	-0.01	17
Battalion 18	-0.01	17
Battalion 19	-0.01	17
Battalion 29	-0.01	17
Battalion 8	-0.02	22
Battalion 23	-0.02	22
Battalion 31	-0.03	24
Battalion 33	-0.03	24
Battalion 30	-0.05	26
Battalion 40	-0.05	26
Battalion 20	-0.06	28
Battalion 41	-0.06	28
Battalion 5	-0.07	30
Battalion 24	-0.07	30
Battalion 28	-0.07	30
Battalion 1	-0.08	33
Battalion 12	-0.09	34
Battalion 21	-0.09	34
Battalion 34	-0.09	34
Battalion 3	-0.11	37
Battalion 25	-0.11	37
Battalion 26	-0.11	37
Battalion 7	-0.13	40
Battalion 32	-0.16	41
Battalion 39	-0.24	42

One Output

BN	Alpha	Rank
Battalion 11	0.31	1
Battalion 38	0.25	2
Battalion 2	0.16	3
Battalion 13	0.02	4
Battalion 14	0.01	5
Battalion 36	0.01	5
Battalion 37	0.01	5
Battalion 6	0.00	8
Battalion 18	-0.01	9
Battalion 27	-0.01	9
Battalion 15	-0.02	11
Battalion 22	-0.02	11
Battalion 8	-0.03	13
Battalion 9	-0.03	13
Battalion 16	-0.03	13
Battalion 29	-0.03	13
Battalion 19	-0.04	17
Battalion 31	-0.04	17
Battalion 10	-0.05	19
Battalion 17	-0.05	19
Battalion 4	-0.06	21
Battalion 35	-0.06	21
Battalion 41	-0.06	21
Battalion 20	-0.07	24
Battalion 24	-0.07	24
Battalion 28	-0.07	24
Battalion 30	-0.07	24
Battalion 40	-0.07	24
Battalion 23	-0.08	29
Battalion 33	-0.08	29
Battalion 21	-0.09	31
Battalion 12	-0.1	32
Battalion 34	-0.1	32
Battalion 25	-0.11	34
Battalion 26	-0.11	34
Battalion 42	-0.11	34
Battalion 5	-0.13	37
Battalion 1	-0.14	38
Battalion 7	-0.16	39
Battalion 3	-0.19	40
Battalion 32	-0.19	40
Battalion 39	-0.25	42

Table 8

Battalion Efficiency Ranking Comparison FY 1993

Two Outputs

BN		Alpha	Rank
Battalion	1	-0.08	33
Battalion	2	0.21	3
Battalion	3	-0.11	37
Battalion	4	0.01	9
Battalion	5	-0.07	30
Battalion	6	0.01	9
Battalion	7	-0.13	40
Battalion	8	-0.02	22
Battalion	9	0.02	7
Battalion	10	0.01	9
Battalion	11	0.31	1
Battalion	12	-0.09	34
Battalion	13	0.03	5
Battalion	14	0.11	4
Battalion	15	-0.01	17
Battalion	16	0	17
Battalion	17	0	15
Battalion	18	-0.01	17
Battalion	19	-0.01	17
Battalion	20	-0.06	28
Battalion	21	-0.09	34
Battalion	22	0.01	9
Battalion	23	-0.02	22
Battalion	24	-0.07	30
Battalion	25	-0.11	37
Battalion	26	-0.11	37
Battalion	27	0.03	5
Battalion	28	-0.07	30
Battalion	29	-0.01	17
Battalion	30	-0.05	26
Battalion	31	-0.03	24
Battalion	32	-0.16	41
Battalion	33	-0.03	24
Battalion	34	-0.09	34
Battalion	35	0.01	9
Battalion	36	0.01	9
Battalion	37	0.02	7
Battalion	38	0.29	2
Battalion	39	-0.24	42
Battalion	40	-0.05	26
Battalion	41	-0.06	28
Battalion	42	0	15

One Outputs

BN		Alpha	Rank
Battalion	1	-0.14	38
Battalion	2	0.16	3
Battalion	3	-0.19	40
Battalion	4	-0.06	21
Battalion	5	-0.13	37
Battalion	6	0	8
Battalion	7	-0.16	39
Battalion	8	-0.03	13
Battalion	9	-0.03	13
Battalion	10	-0.05	19
Battalion	11	0.31	1
Battalion	12	-0.1	32
Battalion	13	0.02	4
Battalion	14	0.01	5
Battalion	15	-0.02	11
Battalion	16	-0.03	13
Battalion	17	-0.05	19
Battalion	18	-0.01	9
Battalion	19	-0.04	17
Battalion	20	-0.07	24
Battalion	21	-0.09	31
Battalion	22	-0.02	11
Battalion	23	-0.08	29
Battalion	24	-0.07	24
Battalion	25	-0.11	34
Battalion	26	-0.11	34
Battalion	27	-0.01	9
Battalion	28	-0.07	24
Battalion	29	-0.03	13
Battalion	30	-0.07	24
Battalion	31	-0.04	17
Battalion	32	-0.19	40
Battalion	33	-0.08	29
Battalion	34	-0.1	32
Battalion	35	-0.06	21
Battalion	36	0.01	5
Battalion	37	0.01	5
Battalion	38	0.25	2
Battalion	39	-0.25	42
Battalion	40	-0.07	24
Battalion	41	-0.06	21
Battalion	42	-0.11	34

the recruiter and local advertising effects quickly became apparent. Here the recruiter elasticity ranged from 0.70 to 0.76, and it would appear that now the mission effects are subsumed in the recruiter activity. Effects of unemployment, local advertising and national advertising are comparable at approximately 0.10.

The constrained goal programming method is a sound estimation device. However, its accuracy (as with traditional statistical regressions) will hinge on there being a sufficient number of observations to alleviate the problem of non-uniqueness. It is expected that a much improved estimation can be achieved by moving to the recruiting company level of analysis provided adequate data are available.

SUMMARY AND RECOMMENDATIONS

New techniques and procedures presented here provide significant improvement over the original DEA and goal programming estimation models used in the FAARRS-SHARE system. This tends to confirm that our new methodology is an appropriate way in which to model Reserve recruiting, although several important data issues would have to be resolved for a full scale application. It also strongly suggests that modeling efforts of Active Army recruiting would also be enhanced by our new approach.

The sensitivity technique discussed in DEA Analyses section has been demonstrated here and in other situations to be an important supplemental tool when analyzing performances using DEA. Not only are individual classifications more thoroughly investigated, but entire groups within the data can be analyzed through properties of their DEA residuals, bringing out information in the data that was undetectable before.

Multiple observations (e.g., quarterly) of battalions provide additional rewards. Since the residual (radius of classification preservation) for a battalion can be viewed as a random variable (a function of partially random data), the computed value is merely a single realization of this random quantity. Multiple observations translate into multiple realizations, and considerable statistical explorations are subsequently possible, not least of which concerns the expected value of an individual battalion's residual. One-sided tests of hypotheses about the expected value of the residual (i.e., < 0 or > 0) would then address the nature of a battalion's expected performance. When drawing statistical inferences about efficiency based upon distributional properties of the residual, one should not overlook the simplification brought about by using a univariate random variable. An abundance of powerful statistical tests and procedures are therefore available.

The DEA also provides additional important information not immediately relevant to the current research focus. This detailed information is readily available as required for routine battalion management including resource allocation and missioning, and we recommend quarterly or semi-annual applications of DEA for such purposes.

As data become more standardized and available on a more finely disaggregated basis, we recommend that the recruiting company (rather than the battalion) be considered as the new basic unit of analysis. In particular, this is likely to improve our estimation procedures for

production function elasticities. In future research it would also be desirable to investigate other flexible function forms for the production function estimation as well as alternative means for model validation.

References

Charnes, A. Golany, B., Kress, M., Pitaktong, U., Rousseau, J. J., Semple, J. H., Song, T., & Zhou, L. (1992). Final report: Enhanced FAARRS-SHARE system (Research Report CCS 683). Austin, TX: Center for Cybernetic Studies, The University of Texas as Austin.

Charnes, A., Golany, B., Kress, M., Rousseau, J. J., & Semple, J. H. (1995). Sensitivity and stability of efficiency classifications in data envelopment analysis. Journal of Productivity Analysis.

Charnes, A., Golany, B., Pitaktong, U., Rousseau, J. J., Semple, J. H., Song, T., & Zhou, L. (1991). Final report: FAARRS-SHARE system (Research Report CCS 671). Austin, TX: Center for Cybernetic Studies, The University of Texas as Austin.

Freed, N., & Glover, F. F. (1981). Simple but powerful goal programming model for discriminant problems. European Journal of Operational Research, 7, 44-60.

Golany, B., & Yu, G. (1995). A goal programming-discriminant function approach to the estimation of an empirical production function based on DEA results. Journal of Productivity Analysis, 6, 171-186.

Rousseau, J. J., & Semple, J. H. (1995). Radii of classification preservation in data envelopment analysis: A case study of "program follow-through". Journal of Operational Research Society, 46(1).

Thomas, D. A. (1990). Data envelopment analysis methods in the management of personnel recruitment under competition in the context of U.S. Army recruiting. Unpublished doctoral dissertation, Graduate School of Business, The University of Texas at Austin.

APPENDIX

Table A1

First Quarter FY93

DMU #		ALPHA	PRODUCTION NPS	PRODUCTION PS	PRODUCTION TOT	MISSION NPS	MISSION PS	MISSION TOT	PROP. ACHIEVED NPS	PROP. ACHIEVED PS	PROP. ACHIEVED TOT	RCRTS	WRITE RATE NPS	WRITE RATE PS	WRITE RATE TOT
Battalion	17	0.22	126	229	355	150	198	348	0.84	1.16	1.02	37	3.41	6.19	9.59
Battalion	38	0.18	87	108	195	93	67	160	0.94	1.61	1.22	29	3.00	3.72	6.72
Battalion	2	0.14	257	270	527	281	222	503	0.91	1.22	1.05	68	3.78	3.97	7.75
Battalion	14	0.14	107	89	196	95	63	158	1.13	1.41	1.24	24	4.46	3.71	8.17
Battalion	22	0.13	126	198	324	109	171	280	1.16	1.16	1.16	31	4.06	6.39	10.45
Battalion	21	0.12	59	89	148	56	99	155	1.05	0.90	0.95	18	3.28	4.94	8.22
Battalion	27	0.09	85	103	188	55	71	126	1.55	1.45	1.49	18	4.72	5.72	10.44
Battalion	9	0.06	131	113	244	128	71	199	1.02	1.59	1.23	26	5.04	4.35	9.38
Battalion	42	0.05	64	141	205	130	88	218	0.49	1.60	0.94	24	2.67	5.88	8.54
Battalion	34	0.04	209	180	389	229	141	370	0.91	1.28	1.05	52	4.02	3.46	7.48
Battalion	36	0.04	120	102	222	135	85	220	0.89	1.20	1.01	22	5.45	4.64	10.09
Battalion	10	0.03	115	212	327	169	179	348	0.68	1.18	0.94	40	2.88	5.30	8.18
Battalion	13	0.03	55	56	111	38	44	82	1.45	1.27	1.35	14	3.93	4.00	7.93
Battalion	15	0.02	110	99	209	81	100	181	1.36	0.99	1.15	24	4.58	4.13	8.71
Battalion	40	0.01	105	98	203	129	84	213	0.81	1.17	0.95	28	3.75	3.50	7.25
Battalion	4	0.00	184	139	323	184	132	316	1.00	1.05	1.02	42	4.38	3.31	7.69
Battalion	6	0.00	104	124	228	137	59	196	0.76	2.10	1.16	24	4.33	5.17	9.50
Battalion	11	0.00	86	117	203	77	108	185	1.12	1.08	1.10	22	3.91	5.32	9.23
Battalion	12	-0.01	87	94	181	99	98	197	0.88	0.96	0.92	21	4.14	4.48	8.62
Battalion	18	-0.01	49	70	119	44	51	95	1.11	1.37	1.25	12	4.08	5.83	9.92
Battalion	20	-0.01	121	154	275	103	177	280	1.17	0.87	0.98	34	3.56	4.53	8.09
Battalion	30	-0.01	95	76	171	84	63	147	1.13	1.21	1.16	20	4.75	3.80	8.55
Battalion	33	-0.01	130	136	266	139	118	257	0.94	1.15	1.04	33	3.94	4.12	8.06
Battalion	8	-0.02	182	214	396	261	178	439	0.70	1.20	0.90	55	3.31	3.89	7.20
Battalion	29	-0.02	140	188	328	164	190	354	0.85	0.99	0.93	42	3.33	4.48	7.81
Battalion	32	-0.02	175	157	332	217	197	414	0.81	0.80	0.80	46	3.80	3.41	7.22
Battalion	41	-0.02	125	118	243	162	97	259	0.77	1.22	0.94	26	4.81	4.54	9.35
Battalion	16	-0.03	60	100	160	66	82	148	0.91	1.22	1.08	20	3.00	5.00	8.00
Battalion	23	-0.04	85	61	146	93	48	141	0.91	1.27	1.04	21	4.05	2.90	6.95
Battalion	35	-0.04	58	96	154	88	54	142	0.66	1.78	1.08	17	3.41	5.65	9.06
Battalion	31	-0.05	131	120	251	153	111	264	0.86	1.08	0.95	38	3.45	3.16	6.61
Battalion	5	-0.07	234	225	459	243	285	528	0.96	0.79	0.87	62	3.77	3.63	7.40
Battalion	28	-0.07	112	146	258	159	110	269	0.70	1.33	0.96	34	3.29	4.29	7.59
Battalion	37	-0.07	34	37	71	38	25	63	0.89	1.48	1.13	8	4.25	4.63	8.88
Battalion	3	-0.08	233	172	405	286	217	503	0.81	0.79	0.81	67	3.48	2.57	6.04
Battalion	25	-0.08	143	177	320	165	172	337	0.87	1.03	0.95	49	2.92	3.61	6.53
Battalion	7	-0.09	179	240	419	289	294	583	0.62	0.82	0.72	59	3.03	4.07	7.10
Battalion	19	-0.09	52	67	119	51	63	114	1.02	1.06	1.04	17	3.06	3.94	7.00
Battalion	24	-0.09	57	49	106	52	49	101	1.10	1.00	1.05	15	3.80	3.27	7.07
Battalion	26	-0.11	61	66	127	60	52	112	1.02	1.27	1.13	20	3.05	3.30	6.35
Battalion	1	-0.13	178	151	329	266	158	424	0.67	0.96	0.78	56	3.18	2.70	5.88
Battalion	39	-0.30	111	118	229	219	144	363	0.51	0.82	0.63	49	2.27	2.41	4.67
		TOTAL	4962	5499	10461	5777	5015	10792	0.86	1.10	0.97	1364	3.64	4.03	7.67

Table A2

Second Quarter FY93

DMU#		ALPHA	PRODUCTION NPS	PRODUCTION PS	PRODUCTION TOT	MISSION NPS	MISSION PS	MISSION TOT	PROP. ACHIEVED NPS	PROP. ACHIEVED PS	PROP. ACHIEVED TOT	RCRTS	WRITE RATE NPS	WRITE RATE PS	WRITE RATE TOT
Battalion	14	0.43	143	88	231	104	81	185	1.38	1.09	1.25	24	5.96	3.67	9.63
Battalion	38	0.33	111	124	235	107	91	198	1.04	1.36	1.19	29	3.83	4.28	8.10
Battalion	2	0.23	367	243	610	271	295	566	1.35	0.82	1.08	65	5.65	3.74	9.38
Battalion	42	0.18	95	168	263	132	142	274	0.72	1.18	0.96	22	4.32	7.64	11.95
Battalion	22	0.11	180	173	353	147	150	297	1.22	1.15	1.19	29	6.21	5.97	12.17
Battalion	34	0.06	229	240	469	293	157	450	0.78	1.53	1.04	50	4.58	4.80	9.38
Battalion	4	0.04	264	127	391	176	191	367	1.50	0.66	1.07	41	6.44	3.10	9.54
Battalion	17	0.04	189	201	390	164	169	333	1.15	1.19	1.17	35	5.40	5.74	11.14
Battalion	36	0.04	133	119	252	115	68	183	1.16	1.75	1.38	23	5.78	5.17	10.96
Battalion	13	0.03	80	52	132	53	46	99	1.51	1.13	1.33	14	5.71	3.71	9.43
Battalion	27	0.03	80	100	180	69	78	147	1.16	1.28	1.22	18	4.44	5.56	10.00
Battalion	29	0.03	226	200	426	164	211	375	1.38	0.95	1.14	41	5.51	4.88	10.39
Battalion	23	0.02	133	71	204	90	92	182	1.48	0.77	1.12	21	6.33	3.38	9.71
Battalion	21	0.01	97	71	168	73	74	147	1.33	0.96	1.14	15	6.47	4.73	11.20
Battalion	35	0.01	63	104	167	83	80	163	0.76	1.30	1.02	15	4.20	6.93	11.13
Battalion	41	0.01	155	150	305	140	114	254	1.11	1.32	1.20	25	6.20	6.00	12.20
Battalion	18	0.00	66	66	132	54	50	104	1.22	1.32	1.27	12	5.50	5.50	11.00
Battalion	9	-0.01	149	95	244	101	109	210	1.48	0.87	1.16	26	5.73	3.65	9.38
Battalion	10	-0.01	210	188	398	180	195	375	1.17	0.96	1.06	40	5.25	4.70	9.95
Battalion	15	-0.01	142	104	246	90	121	211	1.58	0.86	1.17	24	5.92	4.33	10.25
Battalion	28	-0.01	179	144	323	190	118	308	0.94	1.22	1.05	32	5.59	4.50	10.09
Battalion	37	-0.01	45	44	89	40	32	72	1.13	1.38	1.24	8	5.63	5.50	11.13
Battalion	40	-0.01	127	101	228	119	112	231	1.07	0.90	0.99	25	5.08	4.04	9.12
Battalion	7	-0.02	272	245	517	294	320	614	0.93	0.77	0.84	59	4.61	4.15	8.76
Battalion	11	-0.02	119	107	226	98	95	193	1.21	1.13	1.17	21	5.67	5.10	10.76
Battalion	16	-0.02	103	98	201	84	85	169	1.23	1.15	1.19	20	5.15	4.90	10.05
Battalion	20	-0.02	167	135	302	128	134	262	1.30	1.01	1.15	32	5.22	4.22	9.44
Battalion	8	-0.03	260	204	464	238	257	495	1.09	0.79	0.94	52	5.00	3.92	8.92
Battalion	12	-0.03	114	92	206	91	94	185	1.25	0.98	1.11	21	5.43	4.38	9.81
Battalion	19	-0.03	93	64	157	70	73	143	1.33	0.88	1.10	16	5.81	4.00	9.81
Battalion	24	-0.03	74	64	138	63	53	116	1.17	1.21	1.19	15	4.93	4.27	9.20
Battalion	30	-0.03	112	59	171	88	72	160	1.27	0.82	1.07	19	5.89	3.11	9.00
Battalion	33	-0.03	159	122	281	167	135	302	0.95	0.90	0.93	31	5.13	3.94	9.06
Battalion	1	-0.04	267	158	425	216	235	451	1.24	0.67	0.94	51	5.24	3.10	8.33
Battalion	5	-0.04	321	192	513	277	302	579	1.16	0.64	0.89	58	5.53	3.31	8.84
Battalion	6	-0.04	114	106	220	93	101	194	1.23	1.05	1.13	23	4.96	4.61	9.57
Battalion	25	-0.04	192	226	418	220	191	411	0.87	1.18	1.02	49	3.92	4.61	8.53
Battalion	32	-0.07	216	158	374	208	247	455	1.04	0.64	0.82	43	5.02	3.67	8.70
Battalion	3	-0.08	299	164	463	256	278	534	1.17	0.59	0.87	61	4.90	2.69	7.59
Battalion	31	-0.09	175	112	287	196	116	312	0.89	0.97	0.92	37	4.73	3.03	7.76
Battalion	26	-0.17	80	58	138	89	60	149	0.90	0.97	0.93	19	4.21	3.05	7.26
Battalion	39	-0.23	175	135	310	232	232	464	0.75	0.58	0.67	49	3.57	2.76	6.33
		TOTAL	6775	5472	12247	6063	5856	11919	1.12	0.93	1.03	1310	5.17	4.18	9.35

Table A3

Third Quarter FY93

DMU#		ALPHA	PRODUCTION			MISSION			PROP. ACHIEVED			RCRTS	WRITE RATE		
			NPS	PS	TOT	NPS	PS	TOT	NPS	PS	TOT		NPS	PS	TOT
Battalion	2	0.25	299	263	562	261	279	540	1.15	0.94	1.04	60	4.98	4.38	9.37
Battalion	4	0.22	190	148	338	159	172	331	1.19	0.86	1.02	40	4.75	3.70	8.45
Battalion	38	0.18	59	87	146	73	77	150	0.81	1.13	0.97	27	2.19	3.22	5.41
Battalion	6	0.16	106	118	224	91	100	191	1.16	1.18	1.17	23	4.61	5.13	9.74
Battalion	19	0.11	96	47	143	59	62	121	1.63	0.76	1.18	14	6.86	3.36	10.21
Battalion	10	0.09	115	204	319	167	182	349	0.69	1.12	0.91	39	2.95	5.23	8.18
Battalion	14	0.09	110	88	198	79	80	159	1.39	1.10	1.25	22	5.00	4.00	9.00
Battalion	36	0.06	103	111	214	86	62	148	1.20	1.79	1.45	21	4.90	5.29	10.19
Battalion	9	0.05	140	97	237	112	114	226	1.25	0.85	1.05	25	5.60	3.88	9.48
Battalion	17	0.05	96	187	283	139	144	283	0.69	1.30	1.00	35	2.74	5.34	8.09
Battalion	22	0.05	133	161	294	134	132	266	0.99	1.22	1.11	28	4.75	5.75	10.50
Battalion	37	0.04	35	42	77	36	20	56	0.97	2.10	1.38	8	4.38	5.25	9.63
Battalion	35	0.03	51	85	136	71	49	120	0.72	1.73	1.13	15	3.40	5.67	9.07
Battalion	18	0.02	53	66	119	47	49	96	1.13	1.35	1.24	12	4.42	5.50	9.92
Battalion	42	0.02	69	141	210	111	93	204	0.62	1.52	1.03	24	2.88	5.88	8.75
Battalion	11	0.01	91	97	188	69	80	149	1.32	1.21	1.26	20	4.55	4.85	9.40
Battalion	27	0.01	64	100	164	74	74	148	0.86	1.35	1.11	17	3.76	5.88	9.65
Battalion	28	0.01	145	146	291	133	134	267	1.09	1.09	1.09	32	4.53	4.56	9.09
Battalion	31	0.01	136	154	290	147	135	282	0.93	1.14	1.03	34	4.00	4.53	8.53
Battalion	33	0.01	137	108	245	153	166	319	0.90	0.65	0.77	28	4.89	3.86	8.75
Battalion	13	0.00	65	57	122	48	50	98	1.35	1.14	1.24	13	5.00	4.38	9.38
Battalion	29	0.00	157	188	345	138	203	341	1.14	0.93	1.01	39	4.03	4.82	8.85
Battalion	8	-0.01	189	215	404	217	236	453	0.87	0.91	0.89	48	3.94	4.48	8.42
Battalion	15	-0.01	116	98	214	89	90	179	1.30	1.09	1.20	24	4.83	4.08	8.92
Battalion	20	-0.01	109	145	254	121	130	251	0.90	1.12	1.01	31	3.52	4.68	8.19
Battalion	30	-0.01	92	79	171	80	80	160	1.15	0.99	1.07	18	5.11	4.39	9.50
Battalion	41	-0.03	124	108	232	105	92	197	1.18	1.17	1.18	24	5.17	4.50	9.67
Battalion	16	-0.04	85	89	174	76	84	160	1.12	1.06	1.09	19	4.47	4.68	9.16
Battalion	40	-0.05	94	92	186	105	71	176	0.90	1.30	1.06	24	3.92	3.83	7.75
Battalion	26	-0.06	65	68	133	73	74	147	0.89	0.92	0.90	15	4.33	4.53	8.87
Battalion	5	-0.07	265	183	448	254	275	529	1.04	0.67	0.85	58	4.57	3.16	7.72
Battalion	21	-0.07	58	73	131	64	66	130	0.91	1.11	1.01	15	3.87	4.87	8.73
Battalion	24	-0.07	50	57	107	44	58	102	1.14	0.98	1.05	14	3.57	4.07	7.64
Battalion	25	-0.07	179	166	345	175	180	355	1.02	0.92	0.97	49	3.65	3.39	7.04
Battalion	1	-0.08	199	158	357	194	209	403	1.03	0.76	0.89	48	4.15	3.29	7.44
Battalion	23	-0.09	93	57	150	79	83	162	1.18	0.69	0.93	20	4.65	2.85	7.50
Battalion	12	-0.12	75	72	147	84	87	171	0.89	0.83	0.86	20	3.75	3.60	7.35
Battalion	7	-0.14	189	211	400	266	293	559	0.71	0.72	0.72	62	3.05	3.40	6.45
Battalion	34	-0.15	165	146	311	205	193	398	0.80	0.76	0.78	47	3.51	3.11	6.62
Battalion	3	-0.17	184	130	314	224	246	470	0.82	0.53	0.67	50	3.68	2.60	6.28
Battalion	32	-0.21	130	116	246	183	212	395	0.71	0.55	0.62	40	3.25	2.90	6.15
Battalion	39	-0.21	139	126	265	188	170	358	0.74	0.74	0.74	47	2.96	2.68	5.64
		TOTAL	5050	5084	10134	5213	5386	10599	0.97	0.94	0.96	1249	4.04	4.07	8.11

Table A4

Fourth Quarter FY 93

DMU#		ALPHA	PRODUCTION NPS	PRODUCTION PS	PRODUCTION TOT	MISSION NPS	MISSION PS	MISSION TOT	PROP. ACHIEVED NPS	PROP. ACHIEVED PS	PROP. ACHIEVED TOT	RCRTS	WRITE RATE NPS	WRITE RATE PS	WRITE RATE TOT
Battalion	11	0.63	437	509	946	344	430	774	1.27	1.18	1.22	20	21.85	25.45	47.30
Battalion	14	0.14	136	61	197	69	88	157	1.97	0.69	1.25	24	5.67	2.54	8.21
Battalion	31	0.08	123	120	243	59	95	154	2.08	1.26	1.58	31	3.97	3.87	7.84
Battalion	37	0.08	27	39	66	27	13	40	1.00	3.00	1.65	7	3.86	5.57	9.43
Battalion	16	0.06	62	114	176	48	70	118	1.29	1.63	1.49	18	3.44	6.33	9.78
Battalion	35	0.05	34	86	120	44	54	98	0.77	1.59	1.22	15	2.27	5.73	8.00
Battalion	36	0.05	95	79	174	69	37	106	1.38	2.14	1.64	20	4.75	3.95	8.70
Battalion	38	0.05	70	90	160	46	73	119	1.52	1.23	1.34	24	2.92	3.75	6.67
Battalion	2	0.03	329	237	566	186	273	459	1.77	0.87	1.23	61	5.39	3.89	9.28
Battalion	6	0.03	116	134	250	67	103	170	1.73	1.30	1.47	23	5.04	5.83	10.87
Battalion	5	0.01	309	216	525	200	273	473	1.55	0.79	1.11	59	5.24	3.66	8.90
Battalion	9	0.00	137	112	249	78	121	199	1.76	0.93	1.25	28	4.89	4.00	8.89
Battalion	19	0.00	79	56	135	44	53	97	1.80	1.06	1.39	14	5.64	4.00	9.64
Battalion	13	-0.01	59	55	114	32	46	78	1.84	1.20	1.46	12	4.92	4.58	9.50
Battalion	15	-0.01	114	95	209	60	88	148	1.90	1.08	1.41	23	4.96	4.13	9.09
Battalion	4	-0.02	207	139	346	113	173	286	1.83	0.80	1.21	39	5.31	3.56	8.87
Battalion	23	-0.03	89	74	163	62	80	142	1.44	0.93	1.15	19	4.68	3.89	8.58
Battalion	18	-0.04	56	49	105	34	44	78	1.65	1.11	1.35	11	5.09	4.45	9.55
Battalion	22	-0.04	108	160	268	92	122	214	1.17	1.31	1.25	29	3.72	5.52	9.24
Battalion	28	-0.04	99	153	252	99	118	217	1.00	1.30	1.16	28	3.54	5.46	9.00
Battalion	41	-0.04	124	97	221	75	98	173	1.65	0.99	1.28	25	4.96	3.88	8.84
Battalion	42	-0.04	59	150	209	82	124	206	0.72	1.21	1.01	26	2.27	5.77	8.04
Battalion	10	-0.05	135	211	346	142	178	320	0.95	1.19	1.08	38	3.55	5.55	9.11
Battalion	27	-0.05	59	98	157	48	81	129	1.23	1.21	1.22	16	3.69	6.13	9.81
Battalion	29	-0.05	149	218	367	132	203	335	1.13	1.07	1.10	39	3.82	5.59	9.41
Battalion	17	-0.06	130	177	307	128	144	272	1.02	1.23	1.13	36	3.61	4.92	8.53
Battalion	24	-0.06	24	64	88	23	58	81	1.04	1.10	1.09	12	2.00	5.33	7.33
Battalion	12	-0.07	85	91	176	63	80	143	1.35	1.14	1.23	19	4.47	4.79	9.26
Battalion	40	-0.07	107	101	208	102	70	172	1.05	1.44	1.21	22	4.86	4.59	9.45
Battalion	20	-0.08	108	150	258	94	133	227	1.15	1.13	1.14	34	3.18	4.41	7.59
Battalion	26	-0.09	61	74	135	49	60	109	1.24	1.23	1.24	14	4.36	5.29	9.64
Battalion	30	-0.09	79	73	152	63	65	128	1.25	1.12	1.19	18	4.39	4.06	8.44
Battalion	1	-0.11	205	154	359	142	215	357	1.44	0.72	1.01	43	4.77	3.58	8.35
Battalion	33	-0.11	122	104	226	92	136	228	1.33	0.76	0.99	28	4.36	3.71	8.07
Battalion	8	-0.12	199	218	417	182	229	411	1.09	0.95	1.01	49	4.06	4.45	8.51
Battalion	21	-0.12	73	75	148	55	74	129	1.33	1.01	1.15	17	4.29	4.41	8.71
Battalion	3	-0.16	210	128	338	180	236	416	1.17	0.54	0.81	48	4.38	2.67	7.04
Battalion	32	-0.16	174	103	277	164	190	354	1.06	0.54	0.78	41	4.24	2.51	6.76
Battalion	39	-0.17	126	164	290	104	205	309	1.21	0.80	0.94	45	2.80	3.64	6.44
Battalion	7	-0.18	244	184	428	245	268	513	1.00	0.69	0.83	57	4.28	3.23	7.51
Battalion	25	-0.19	155	184	339	171	183	354	0.91	1.01	0.96	49	3.16	3.76	6.92
Battalion	34	-0.23	152	136	288	168	185	353	0.90	0.74	0.82	49	3.10	2.78	5.88
		TOTAL	5466	5532	10998	4277	5569	9846	1.28	0.99	1.12	1230	4.44	4.50	8.94

Table A5

Aggregate FY 93

BN	ALPHA	PRODUCTION NPS	PRODUCTION PS	PRODUCTION TOT	MISSION NPS	MISSION PS	MISSION TOT	PROP. ACHIEVED NPS	PROP. ACHIEVED PS	PROP. ACHIEVED TOT	RCRTS	WRITE RATE NPS	WRITE RATE PS	WRITE RATE TOT
Battalion 11	0.31	733	830	1563	588	713	1301	1.25	1.16	1.20	21	35.33	40.00	75.33
Battalion 38	0.29	327	409	736	319	308	627	1.03	1.33	1.17	27	12.00	15.01	27.01
Battalion 2	0.21	1252	1013	2265	999	1069	2068	1.25	0.95	1.10	64	19.72	15.95	35.67
Battalion 14	0.11	496	326	822	347	312	659	1.43	1.04	1.25	24	21.11	13.87	34.98
Battalion 13	0.03	259	220	479	171	186	357	1.51	1.18	1.34	13	19.55	16.60	36.15
Battalion 27	0.03	288	401	689	246	304	550	1.17	1.32	1.25	17	16.70	23.25	39.94
Battalion 9	0.02	557	417	974	419	415	834	1.33	1.00	1.17	26	21.22	15.89	37.10
Battalion 37	0.02	141	162	303	141	90	231	1.00	1.80	1.31	8	18.19	20.90	39.10
Battalion 4	0.01	845	553	1398	632	668	1300	1.34	0.83	1.08	41	20.86	13.65	34.52
Battalion 6	0.01	440	482	922	388	363	751	1.13	1.33	1.23	23	18.92	20.73	39.66
Battalion 10	0.01	575	815	1390	658	734	1392	0.87	1.11	1.00	39	14.65	20.76	35.41
Battalion 22	0.01	547	692	1239	482	575	1057	1.13	1.20	1.17	29	18.70	23.66	42.36
Battalion 35	0.01	206	371	577	286	237	523	0.72	1.57	1.10	16	13.29	23.94	37.23
Battalion 36	0.01	451	411	862	405	252	657	1.11	1.63	1.31	22	20.98	19.12	40.09
Battalion 17	0	541	794	1335	581	655	1236	0.93	1.21	1.08	36	15.13	22.21	37.34
Battalion 42	0	287	600	887	455	447	902	0.63	1.34	0.98	24	11.96	25.00	36.96
Battalion 15	-0.01	482	396	878	320	399	719	1.51	0.99	1.22	24	20.29	16.67	36.97
Battalion 16	-0.01	310	401	711	274	321	595	1.13	1.25	1.19	19	16.10	20.83	36.94
Battalion 18	-0.01	224	251	475	179	194	373	1.25	1.29	1.27	12	19.06	21.36	40.43
Battalion 19	-0.01	320	234	554	224	251	475	1.43	0.93	1.17	15	20.98	15.34	36.33
Battalion 29	-0.01	672	794	1466	598	807	1405	1.12	0.98	1.04	40	16.70	19.73	36.42
Battalion 8	-0.02	830	851	1681	898	900	1798	0.92	0.95	0.93	51	16.27	16.69	32.96
Battalion 23	-0.02	400	263	663	324	303	627	1.23	0.87	1.06	20	19.75	12.99	32.74
Battalion 31	-0.03	565	506	1071	555	457	1012	1.02	1.11	1.06	35	16.14	14.46	30.60
Battalion 33	-0.03	548	470	1018	551	555	1106	0.99	0.85	0.92	30	18.27	15.67	33.93
Battalion 30	-0.05	378	287	665	315	280	595	1.20	1.03	1.12	19	20.16	15.31	35.47
Battalion 40	-0.05	433	392	825	455	337	792	0.95	1.16	1.04	25	17.49	15.84	33.33
Battalion 20	-0.06	505	584	1089	446	574	1020	1.13	1.02	1.07	33	15.42	17.83	33.25
Battalion 41	-0.06	528	473	1001	482	401	883	1.10	1.18	1.13	25	21.12	18.92	40.04
Battalion 5	-0.07	1129	816	1945	974	1135	2109	1.16	0.72	0.92	59	19.05	13.77	32.83
Battalion 24	-0.07	205	234	439	182	218	400	1.13	1.07	1.10	14	14.64	16.71	31.36
Battalion 28	-0.07	535	589	1124	581	480	1061	0.92	1.23	1.06	32	16.98	18.70	35.68
Battalion 1	-0.08	849	621	1470	818	817	1635	1.04	0.76	0.90	50	17.15	12.55	29.70
Battalion 12	-0.09	361	349	710	337	359	696	1.07	0.97	1.02	20	17.83	17.23	35.06
Battalion 21	-0.09	287	308	595	248	313	561	1.16	0.98	1.06	16	17.66	18.95	36.62
Battalion 34	-0.09	755	702	1457	895	676	1571	0.84	1.04	0.93	50	15.25	14.18	29.43
Battalion 3	-0.11	926	594	1520	946	977	1923	0.98	0.61	0.79	57	16.39	10.51	26.90
Battalion 25	-0.11	669	753	1422	731	726	1457	0.92	1.04	0.98	49	13.65	15.37	29.02
Battalion 26	-0.11	267	266	533	271	246	517	0.99	1.08	1.03	17	15.71	15.65	31.35
Battalion 7	-0.13	884	880	1764	1094	1175	2269	0.81	0.75	0.78	59	14.92	14.85	29.77
Battalion 32	-0.16	695	534	1229	772	846	1618	0.90	0.63	0.76	43	16.35	12.56	28.92
Battalion 39	-0.24	551	543	1094	743	751	1494	0.74	0.72	0.73	48	11.60	11.43	23.03
	TOTAL	22253	21587	43840	21330	21826	43156	1.04	0.99	1.02	1288	17.27	16.76	34.03